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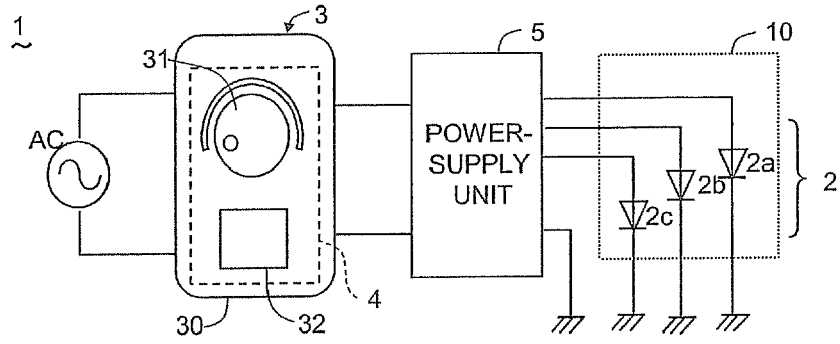
(54) Lighting apparatus

(57) To provide a lighting apparatus capable of easily varying the color of illuminating light in accordance with a desired atmosphere while maintaining vividness of a visual object illuminated with the light, and desirable color appearance.

A lighting apparatus 1 includes: two or more types of light sources 2 having different emission spectrums; a controller 3 that allows setting of a color temperature of illuminating light from the light sources 2; and a control unit 4 that individually controls outputs of the light sources 2 so that the illuminating light has the color temperature set by means of the controller 3. The control unit 4, when the controller 3 has been operated to change the set color temperature, controls outputs of the light sources 2 so that the color temperature is varied in a state where a feeling of contrast index FCI is higher than 123 and a variation width of the FCI keeps within 10. Since the FCI is maintained at a value higher than 123 when the color temperature is changed, the color of the illuminating light can be easily varied in accordance with a desired atmosphere while maintaining vividness of a visual object illuminated by the illuminating light, and the desirable color appearance.

FIG. 1



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Description

[Field of the Invention]

[0001] The present invention relates to a lighting apparatus that changes the color temperature of illuminating light taking into account appearance of color.

[Background of the Invention]

[0002] Conventionally, there has been known a lighting apparatus that renders the color of a visual object vivid to make the color of the visual object look desirable. As an example of such a lighting apparatus, a lighting apparatus has been known in which a color gamut area is increased by additive color mixing of light from red, blue, green, and white LEDs, for example, thereby making the color of a visual object illuminated with illuminating light look vivid (refer to Japanese Laid-Open Patent Publication No. 2011-204659, for example).

[0003] Further, it has been known that vividness of the color of a visual object under an illuminating environment is influenced by conspicuity of the visual object. However, the influence by the conspicuity cannot be appropriately evaluated by an average color rendering index (Ra) that is generally used for conventional evaluation of color rendering property. Therefore, a feeling of contrast index (FCI) as an index for evaluation of conspicuity is used in combination with the Ra, whereby color rendering property of a light source can be multilaterally evaluated more appropriately (refer to "New Version of Color Science Handbook [3rd Edition], The Color Science Association of Japan", for example).

[0004] The FCI is an index indicating the extent of contrast and vividness in color reproduction of a light source, and is defined by the following formula (1):

[0005] [Formula 1]

$$FCI = \left[\frac{G_{LAB}(T)}{G_{LAB}(D65)} \right]^{1.5} \times 100 \quad \cdots (1)$$

where

$G_{LAB}(T)$ is a color gamut area of a color combination sample for four colors of red, blue, green, and yellow in an LAB color system under a test illuminant, and

$G_{LAB}(D65)$ is a color gamut area of the four-color combination sample in the LAB color system under a standard illuminant D65.

[0006] The FCI is 100 under the standard illuminant D65, and an illuminant whose FCI is higher than 100 renders the color more vivid and makes the space look brighter, as compared to the standard illuminant D65. As a lighting apparatus using the FCI as an index for evaluation, there has been known a lighting apparatus in which the types of phosphors used in a discharge lamp and the weight ratio thereof are set so that the FCI of light emitted from the discharge lamp is within a predetermined range (refer to Japanese Patent No. 3040719, for example). Using this lighting apparatus, it is possible to perform lighting that makes the colors of flowers and green leaves appear more conspicuous.

[Brief Summary of the Invention]

[Problems to be Solved by the Invention]

[0007] However, the FCI is lowered as the color temperature increases under a general white light source. Specifically, the FCI of an incandescent lamp whose correlated color temperature is 2700 K is 123, whereas the FCI of a high color-rendering type fluorescent lamp whose correlated color temperature is 5200 K is 104. In recent years, a lighting apparatus has been widely used, which includes a plurality of light sources having different emission colors, and controls the output ratio of the light sources to change the color temperature of illuminating light. However, simply changing the color temperature of the illuminating light might cause unintended change in desirability of color appearance.

[0008] The present invention has been made to solve the above problems, and an object of the present invention is to provide a lighting apparatus that can easily vary the color of illuminating light in accordance with a desired atmosphere while maintaining vividness of a visual object illuminated with the light, and desirable color appearance.

[Solution to the Problems]

[0009] In order to solve the above problems, a lighting apparatus according to the present invention includes: two or more types of light sources having different emission spectrums; an operation unit that allows setting of a color temperature of illuminating light from the light sources; and a control unit that individually controls outputs of the light sources so that the illuminating light has the color temperature set by means of the operation unit. The control unit, when the operation unit has been operated to change the set color temperature, controls outputs of the light sources so that the color temperature is varied in a state where a feeling of contrast index FCI is higher than 123 and a variation width of the FCI keeps within 10.

[0010] In the above-mentioned lighting apparatus, preferably, a variation width of the color temperature of the illuminating light set by means of the operation unit is 2700 K to 5000 K.

[0011] In the above-mentioned lighting apparatus, preferably, the light sources include a light emitting device that emits white light having a relatively high color temperature, a light emitting device that emits white light having a relatively low color temperature, a light emitting device that emits green light, and a light emitting device that emits red light.

[Effects of the Invention]

[0012] According to the present invention, when the color temperature is changed, the feeling of contrast index FCI is maintained at a value higher than 123. Therefore, it is possible to easily vary the color of illuminating light in accordance with a desired atmosphere while maintaining vividness of a visual object illuminated with the light, and desirable color appearance.

[Brief Description of the Drawings]

[0013]

[FIG 1] FIG. 1 is a block diagram showing a lighting apparatus according to an embodiment of the present invention.
[FIG 2] FIGS. 2A to 2E are diagrams showing variations of operation means in a controller of the lighting apparatus.
[FIG 3] FIG. 3A is a perspective view of a lighting fixture in which the lighting apparatus is incorporated, FIG. 3B is an exploded perspective view of the lighting fixture, and FIG. 3C is a top view showing solid state light emitting devices and a circuit board used in the lighting fixture.
[FIG 4] FIG. 4 is a side cross-sectional view of an LED used in the lighting apparatus.
[FIG 5] FIG. 5 is a block diagram showing a power supply unit used in the lighting apparatus.
[FIG. 6] FIG. 6 is a diagram showing a correlation between feeling of contrast index and desirability of color appearance.
[FIG. 7] FIG. 7A is a diagram showing emission spectrums of light sources used in Working Example 1, FIG. 7B is a diagram showing emission spectrums of light sources used in Working Example 2, and FIG. 7C is a diagram showing emission spectrums of light sources used in Comparative Example.
[FIG. 8] FIG. 8 is a diagram showing emission spectrums of illuminating light at color temperatures of 2700 K and 4700 K in the light sources used in Working Example 2.
[FIG. 9] FIG. 9 is a diagram showing correlations between correlated color temperatures and chromas of red color appearance in Working Examples 1 and 2 and Comparative Example.

[Detailed Description of the Invention]

[0014] A lighting apparatus according to an embodiment of the present invention will be described with reference to FIG. 1 to FIG. 9. As shown in FIG. 1, the lighting apparatus 1 according to the present embodiment includes: light sources 2; an operation unit (hereinafter referred to as a controller) 3 for setting a color temperature of illuminating light generated by the light sources 2; and a control unit 4 that controls the outputs of the light sources 2 individually so that the illuminating light has the color temperature set by the controller 3. As the light sources 2, two or more types of solid state light emitting devices (hereinafter referred to as LEDs) having different emission spectrums are used. In FIG. 1, LEDs 2a, 2b, and 2c are used as the light sources 2, and are incorporated in a lighting fixture 10. However, the number of the types of the light sources is not limited to three. In Working Examples described later, two or four types of light sources are used. Further, the lighting apparatus 1 includes a power supply unit 5 that supplies predetermined voltages to the LEDs 2a to 2c, respectively. The power supply unit 5 may be independently configured as shown in FIG. 1, or may be incorporated in the controller 3 or the lighting fixture 10.

[0015] The controller 3 includes: a housing 30; a cylindrical volume switch 31 that allows a user to set a color temperature of illuminating light; and a power switch 32 that allows the user to turn on/off the lighting apparatus 1. The volume switch

31 is provided rotatably with respect to the housing 30, and allows the user to set a desired color temperature. The power switch 32 is composed of a tumbler switch, a pushbutton switch, or the like, and opens and closes a feeding path from an alternating-current power supply AC to the power supply unit 5. The control unit 4 is provided in the housing 30 of the controller 3, and generates a DC voltage signal based on the correlated color temperature set by user operation on the volume switch 31.

[0016] In FIG. 1, the rotary volume switch 31 is shown as an example of the operation means operated by the user. However, the operation means may have other configurations as long as the operation means allows the user to set a desired color temperature. For example, the operation means may be: a fader that is vertically slidable as shown in FIG. 2A; "up" and "down" push buttons as shown in FIG. 2B; or a multistage switch associated with specific color temperatures as shown in FIG. 2C. Alternatively, a rotary volume switch and a multistage switch may be combined as shown in FIG. 2D, or operation means that allows the user to input a numerical value of a color temperature as shown in FIG. 2E may be used. Still alternatively, the above-mentioned buttons and fader may be displayed on a touch panel and represented by colors corresponding to set color temperatures. The display may be made by characters or colors such as orange and blue.

[0017] As shown in FIG. 3A, the lighting fixture 10 is used as a downlight to be embedded in, for example, a ceiling, a wall, or the like. The lighting fixture 10 includes a main body 11 that holds the equipment body, and houses a power supply unit (not shown) for lighting the LEDs 2a to 2c constituting the light sources 2. Further, the lighting fixture 10 includes: a frame 12 that is fitted in an opening formed in a ceiling or the like, and holds the light sources 2 and the like; a terminal block 13 to which a power supply line for receiving power supplied from a commercial power supply is connected; and mounting springs 14 for fixing the frame 12 to the ceiling or the like.

[0018] Further, as shown in FIG. 3B, the lighting fixture 10 includes: a circuit board 15 on which the LEDs 2a to 2c are mounted; a heat sink member 16 for transferring heat of the LEDs 2a to 2c; and a holder member 17 provided between the circuit board 15 and the heat sink member 16. Further, the lighting fixture 10 includes a protection cover 18 for protecting the LEDs 2a to 2c. On the rear side of the protection cover 18, screw holders (not shown) are provided, and the protection cover 18 and the heat sink member 16 are fixed to each other by screws (not shown) inserted into the screw holders from the inner side of the heat sink member 16 (main body 11).

[0019] As shown in FIG. 3C, the LEDs 2a to 2c are arranged in a substantially center area of the circuit board 15 and in the vicinity of the center area, preferably alternately, such that the LEDs of the same type are not adjacent to each other. The arrangement of the LEDs 2a to 2c is not limited to the arrangement shown in FIG. 3C.

[0020] The circuit board 15 is a generic circuit board for a light emitting module, and is made of a material such as: metal oxide (including ceramic) or metal nitride having an electrical insulating property, such as aluminum oxide (Al_2O_3) or aluminum nitride (AlN); metal; resin; or glass fibers. A wiring circuit (not shown) formed on the circuit board 15 is coated with an insulating material, and portions of the wiring circuit connected to positive and negative electrodes of the LEDs 2a to 2c and portions thereof connected to wires are exposed as electrode terminals (not shown).

[0021] As shown in FIG. 4, the light source 2 (each of the LEDs 2a to 2c) includes: a base 20 having a rectangular cross section; a light emitting unit (LED chip) 21 mounted on the base 20; a frame part 22 having a recess in which the LED chip 21 is disposed; and a filler 23 filled in the frame part 22. The filler 23 is silicone or the like, and contains phosphors 24a and 24b that convert the wavelength of light emitted from the LED chip 21. In the example of FIG. 4, two types of phosphors 24a and 24b are used. However, the number of the types of phosphors is not limited to two, and is appropriately adjusted so that the light emitted from the light source 2 has an emission spectrum described later.

[0022] A cathode electrode 25 is provided on one side surface of the base 20 while an anode electrode 26 is provided on the other side surface of the base 20. The cathode electrode 25 and the anode electrode 26 are connected to external connecting electrodes 27 and 28 formed at both ends of a lower surface of the base 20, respectively. Further, the cathode electrode 25 and the anode electrode 26 are connected to electrode terminals (not shown) of the LED chip 21 by wires 29. An inner circumferential surface of the frame part 22 is formed to be a conical surface having an opening in the light outgoing direction, and the conical surface has a light reflecting function.

[0023] Preferably, a blue LED element that emits blue light is used as the LED chip 21, and an LED 2 that emits light of a desired chromaticity is obtained by adjusting the types or contents of the phosphors 24a and 24b. Assuming that the chromaticity coordinates of light colors of the LEDs 2a, 2b, and 2c shown in FIG. 1 are (x_1, y_1), (x_2, y_2), and (x_3, y_3), respectively, and the light amounts of the LEDs 2a, 2b, and 2c are Y_1, Y_2, Y_3, respectively, the chromaticity coordinates (x_0, y_0) of light color of illuminating light as mixed-color light and the light amount Y0 of the illuminating light are represented by the following formula (2). By varying the ratio of the light amounts Y_1, Y_2, and Y_3 of the LEDs 2a, 2b, and 2c, it is possible to vary the color temperature of the illuminating light obtained as the mixed-color light.

[0024] [Formula 2]

$$x_0 = \frac{x_1 \frac{Y_1}{y_1} + x_2 \frac{Y_2}{y_2} + x_3 \frac{Y_3}{y_3}}{\frac{Y_1}{y_1} + \frac{Y_2}{y_2} + \frac{Y_3}{y_3}}$$

$$y_0 = \frac{Y_1 + Y_2 + Y_3}{\frac{Y_1}{y_1} + \frac{Y_2}{y_2} + \frac{Y_3}{y_3}}$$

$$Y_0 = Y_1 + Y_2 + Y_3 \qquad \cdots (2)$$

[0025] In addition to or instead of the phosphors 24a and 24b, a filter (not shown) may be used, which converts the wavelength of the light emitted from the LED 2 by selectively transmitting light of a specific wavelength. Such a filter may be provided in the protection cover 18 (refer to FIG. 3B) of the lighting fixture 10. Further, the LED 2 may be provided with a lens member (not shown) for adaptively controlling distribution of the emitted light. The phosphors 24 or the filter may be incorporated in the lens member or between the LED 2 and the lens member.

[0026] As shown in FIG. 5, the power supply unit 5 includes: a control signal input unit 51 to which a control signal from the controller 3 is input; and an AC/DC converter 52 that converts an AC voltage supplied via the controller 3 into a desired DC voltage. Further, the power supply unit 5 includes: first to third LED drive units 53a to 53c that drive the LEDs 2a to 2c (refer to FIG. 1), respectively; and a drive signal converter 54 that converts the control signal input to the control signal input unit 51 into drive signals to be output to the first to third LED drive units 53a to 53c. The drive signal converter 54 outputs a drive signal composed of a rectangular wave signal having a constant period, whose on-duty ratio is variable, to control, by PWM (Pulse Width Modulation), switching elements (not shown) of the first to third LED drive units 53a to 53c, thereby adjusting the amount of power supplied to the LEDs 2a to 2c.

[0027] In the power supply unit 5, a control signal output from a control signal generator of the controller 3 is converted into a DC voltage signal having a voltage level corresponding to the on-duty ratio (color temperature) by the control signal input unit 51. Then, the DC voltage signal is converted into the drive signals for the first to third LED drive units 53a to 53c by the drive signal converter 54. The drive signal converter 54 includes a microcomputer and a memory. The memory stores therein: the signal level of the DC voltage signal (the color temperature); the chromaticity coordinates (x_0, y_0) of the light color of the illuminating light corresponding to the set color temperature; the ratio of the light amounts Y_1, Y_2, and Y_3 of the LEDs 2a to 2c corresponding to the chromaticity coordinates; and a conversion table representing the correspondence relationship among them. The microcomputer converts the DC voltage signal into a drive signal based on the conversion table stored in the memory.

[0028] An experiment was conducted in which a plant as a visual object was illuminated with illuminating light of various FCIs (feeling of contrast indexes), and desirability of appearance was evaluated. A result of the experiment is shown in FIG. 6. As shown in FIG. 6, the higher the FCI is, the higher the evaluated desirability is. Under the condition where the variation width of the FCI is higher than 10, there is a significant difference in the evaluation. The FCI of an incandescent lamp that is generally said to make a visual object look desirable is 123. So, in the present embodiment, when the controller 3 has been operated to change the set color temperature, the control unit 4 controls the output of each LED so that the color temperature is varied in a state where the FCI is higher than 123 and the variation width of the FCI keeps within 10.

[0029] The FCI is a value defined by the above-mentioned formula (1). That is, the FCI is represented by $[G_{LAB}(T)/G_{LAB}(D65)]^{1.5} \times 100$ where $G_{LAB}(T)$ is a color gamut area of a color combination sample for four colors of red, blue, green, and yellow in an LAB color system under a test illuminant, and $G_{LAB}(D65)$ is a color gamut area of the four-color combination sample in the LAB color system under a standard illuminant D65.

[0030] Hereinafter, the lighting apparatus 1 of the present embodiment will be described with reference to specific Working Examples and Comparative Example.

<Working Example 1>

[0031] A lighting apparatus 1 according to Working Example 1 uses two types of light sources 2, i.e., an incandescent

LED 1a having a high FCI and a low color temperature, and a white LED 2a having a high color temperature, thereby making the correlated color temperature of the illuminating light variable while maintaining a high FCI. FIG. 7A shows the emission spectrums of the LEDs 1a and 2a used as the light sources 2 of Working Example 1. The LED 1a is obtained by coating a GaN-based blue LED chip with a filler to which CASN-based red phosphor is added, and the LED 2a is obtained by coating a GaN-based blue LED chip with a filler to which BOSE-based green phosphor is added. The amounts of the phosphors added to the respective fillers are adjusted.

<Working Example 2>

[0032] A lighting apparatus 1 according to Working Example 2 uses four types of light sources 2, i.e., an incandescent LED 1b having high color rendering property, a white LED 2b having high color rendering property, a GaN-based green LED 3b, and an AlInGaP-based red LED 4b, thereby making the correlated color temperature of the illuminating light variable while maintaining a high FCI. FIG. 7B shows the emission spectrums of the LEDs 1b, 2b, 3b, and 4b used as the light sources 2 of Working Example 2. The LED 1b is obtained by coating a GaN-based blue LED chip with a filler to which CASN-based red phosphor is added, and the LED 2b is obtained by coating a GaN-based blue LED chip with a filler to which BOSE-based green phosphor is added. The amounts of the phosphors added to the respective fillers are adjusted to be different from each other. The LEDs 1b and 2b of Working Example 2 are different from the LEDs 1a and 2a of Working Example 1, respectively, in the amounts of the phosphors added to the fillers. The LED 3b is obtained by coating a GaN-based blue LED chip with a filler to which Ba_2SiO_4:Eu is added, and the LED 4b is obtained by coating a GaN-based blue LED chip with a filler to which $CaAlSiN_3$:Eu is added.

<Comparative Example>

[0033] A lighting apparatus according to Comparative Example uses an LED 1c having a low color temperature and high color rendering property, and an LED 2c having a high color temperature. FIG. 7C shows the emission spectrums of the LEDs 1c and 2c used as the light sources of Comparative Example. The LEDs 1c and 2c are different from the LEDs 1a and 1b and the LEDs 2a and 2b of Working Examples 1 and 2, respectively, in the amounts of the phosphors added to the fillers.

[0034] Regarding the lighting apparatuses 1 according to Working Examples 1 and 2 and the lighting apparatus according to Comparative Example, the volume switch 31 of the controller 3 was operated to set the color temperature in a range from 2700 K to 4700 K (to 5000 K in Working Example 1). This color temperature range realizes illuminating light of incandescent, warm white, white, and natural white that are defined by JIS(Japanese Industrial Standards) Z9112. Further as shown in Table 1 below, the output ratio of the light sources 2 corresponding to each set color temperature is stored in the memory included in the drive signal converter 54 (refer to FIG. 5), and the light amount Y of each LED is controlled so as to correspond to the set color temperature.

[Table 1]

	Correlated color temperature [K]	Output ratio				Feeling of contrast index FCI (difference from MAX value)
		LED 1a	LED 2a			
Working Example 1	2700	0	1	-	-	135 (-2)
	3500	0.62	1	-	-	137 (±0)
	4000	1.6	1	-	-	137 (±0)
	4700	1	0.1	-	-	135 (-2)
	5000	1	0	-	-	135 (-2)
	Correlated color temperature[K]	Output ratio				Feeling of contrast index FCI (difference from MAX value)
		LED 1b	LED 2b	LED 3b	LED 4b	
Working Example 2	2700	0	1	0	0.9	134 (±0)
	3500	1	0.3	0.05	1.5	134 (±0)
	4000	1.2	0	0.1	1.5	133 (-1)
	4700	1	0	0.25	0.855	126 (-8)

(continued)

	Correlated color temperature [K]	Output ratio				Feeling of contrast index FCI (difference from MAX value)
		LED 1c	LED 2c			
Comparative Example	2700	0	1	-	-	126 (±0)
	3500	1	1	-	-	120 (-6)
	4000	3	1	-	-	114 (-12)
	4700	1	0	-	-	105 (-21)

[0035] In Comparative Example, as the user performs an operation to rise the color temperature, the feeling of contrast index FCI is lowered, and the vividness and desirability of appearance of the illuminated object are varied. In contrast, in Working Example 1, even when the user performs an operation to rise the color temperature, the FCI is kept within a certain range, and therefore, vivid and desirable color appearance of the illuminated object is maintained. A similar result is obtained for Working Example 2.

[0036] FIG. 8 shows the emission spectrums of illuminating light output from the light source 2 when the set value of the correlated color temperature is 2700 K and 4700 K, respectively, in Working Example 2. In Working Example 2, since the four LEDs 1b, 2b, 3b, and 4b having different illumination colors are used, it is possible to efficiently obtain, at each set color temperature, a wavelength component required for achieving the color temperature.

[0037] FIG. 9 shows the chroma (Cab*) of red color appearance for each correlated color temperature (CCT) in the lighting apparatuses 1 according to Working Examples 1 and 2 and the lighting apparatus according to Comparative Example. As shown in FIG. 9, in Working Examples 1 and 2, the chroma (Cab*) is higher than 60 at any CCT, and does not vary so much with the variation in the color temperature. On the other hand, in Comparative Example, the chroma (Cab*) is lowered as the CCT increases.

[0038] As described above, in the lighting apparatus 1, when the controller 3 has been operated to change the set color temperature, the color temperature is varied in a state where the feeling of contrast index FCI is higher than 123 and the variation width of the FCI keeps within 10. Since the FCI is maintained at a value higher than 123, the color of illuminating light can be easily varied in accordance with a desired atmosphere while maintaining vividness of a visual object illuminated by the illuminating light, and the desirable color appearance.

[0039] The present invention is not limited to the above-mentioned embodiment, and various modifications can be made. The combination of phosphors to realize spectral distribution of each LED is not limited to that mentioned above. Further, the number of the types of LEDs and the combination thereof are not limited to the number and the combination described in Working Examples. Any types of LEDs and any combination may be adopted so long as the variation in the correlated color temperature and the feeling of contrast index FCI can be maintained.

[Description of Reference Characters]

[0040]

1	lighting apparatus
2	light source
2a, 2b, 2c	LED
3	controller (operation unit)
4	control unit

Claims

1. A lighting apparatus, comprising:

two or more types of light sources having different emission spectrums;
an operation unit that allows setting of a color temperature of illuminating light from the light sources; and
a control unit that individually controls outputs of the light sources so that the illuminating light has the color temperature set by means of the operation unit, wherein
the control unit, when the operation unit has been operated to change the set color temperature, controls outputs of the light sources so that the color temperature is varied in a state where a feeling of contrast index FCI is

higher than 123 and a variation width of the FCI keeps within 10.

2. The lighting apparatus according to claim 1, wherein
a variation width of the color temperature of the illuminating light set by means of the operation unit is 2700 K to 5000 K.

3. The lighting apparatus according to claim 1 or 2, wherein
the light sources include a light emitting device that emits white light having a relatively high color temperature, a light emitting device that emits white light having a relatively low color temperature, a light emitting device that emits green light, and a light emitting device that emits red light.

FIG. 1

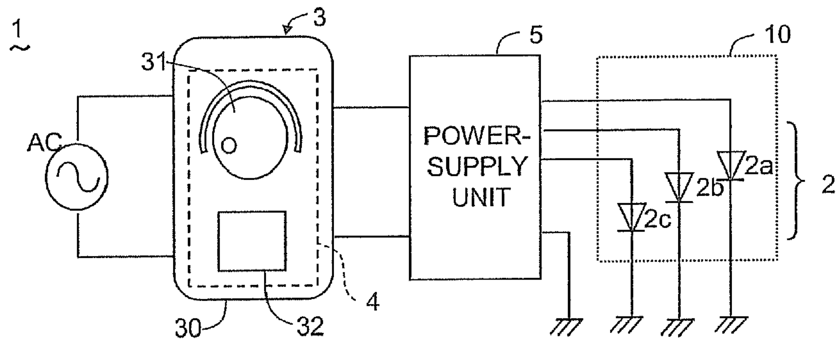


FIG. 2A

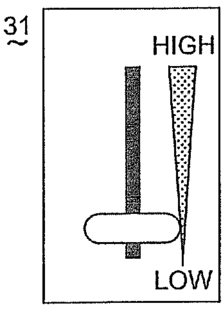


FIG. 2B

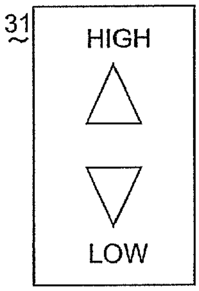


FIG. 2C

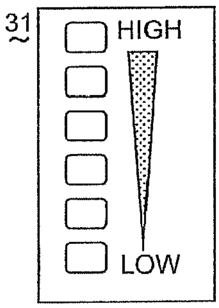


FIG. 2D

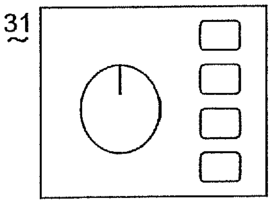


FIG. 2E

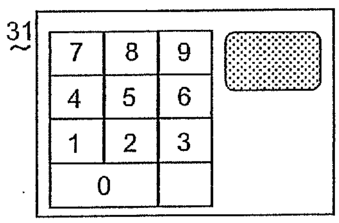


FIG. 3A

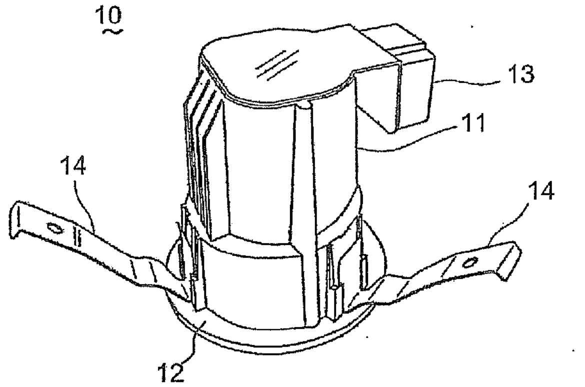


FIG. 3B

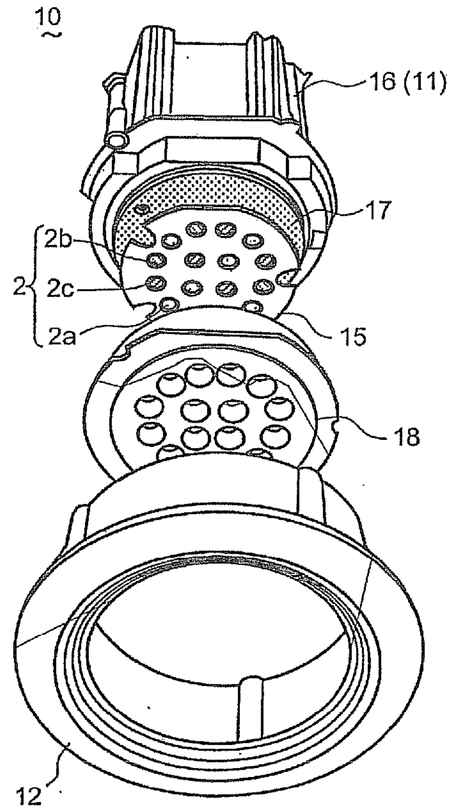


FIG. 3C

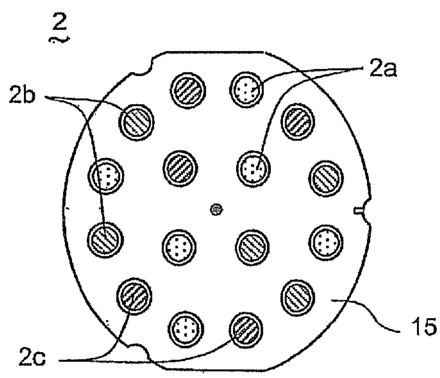


FIG. 4

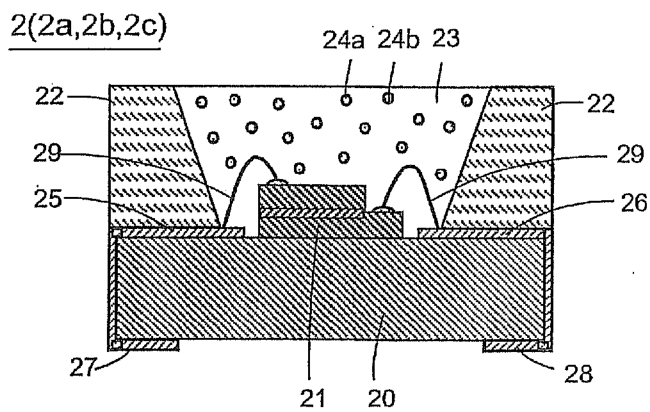


FIG. 5

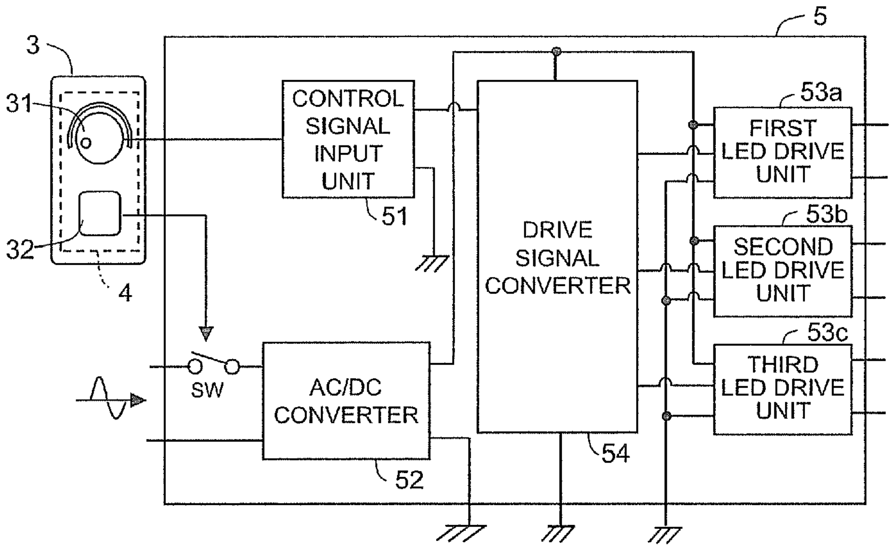

5
3
31
32
4
CONTROL SIGNAL INPUT UNIT
51
SW
AC/DC CONVERTER
52
DRIVE SIGNAL CONVERTER
54
53a
FIRST LED DRIVE UNIT
53b
SECOND LED DRIVE UNIT
53c
THIRD LED DRIVE UNIT

FIG. 6

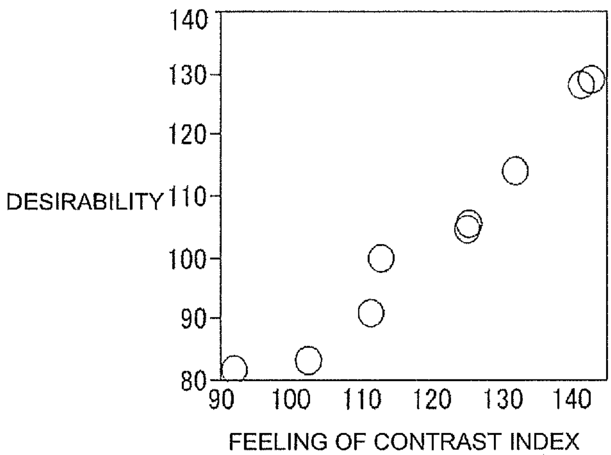

DESIRABILITY
140
130
120
110
100
90
80
90
100
110
120
130
140
FEELING OF CONTRAST INDEX

FIG. 7A

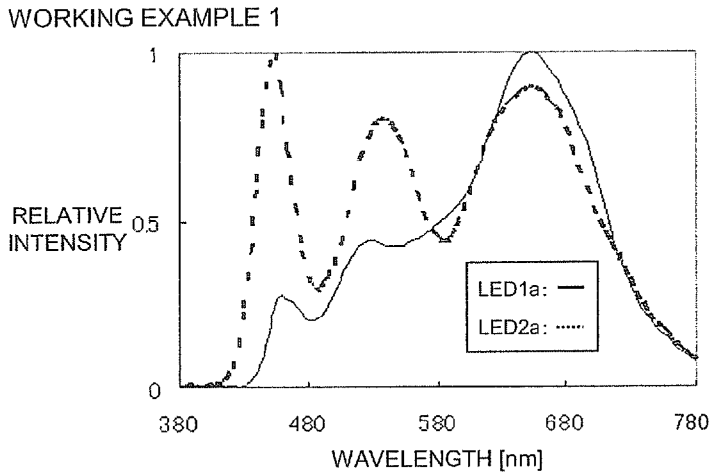


FIG. 7B

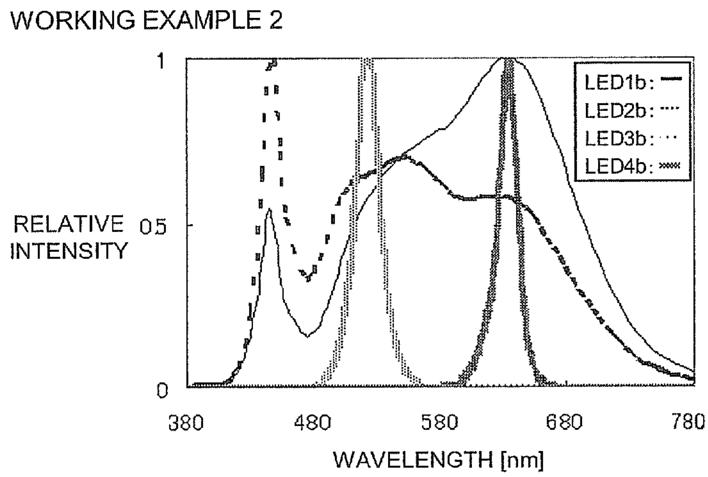


FIG. 7C

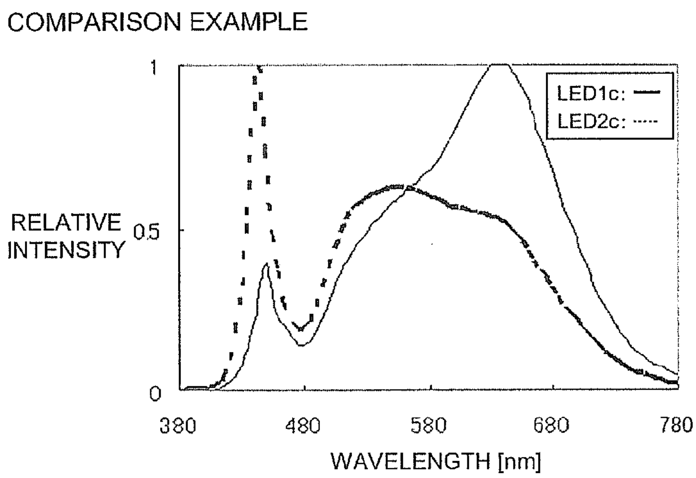


FIG. 8

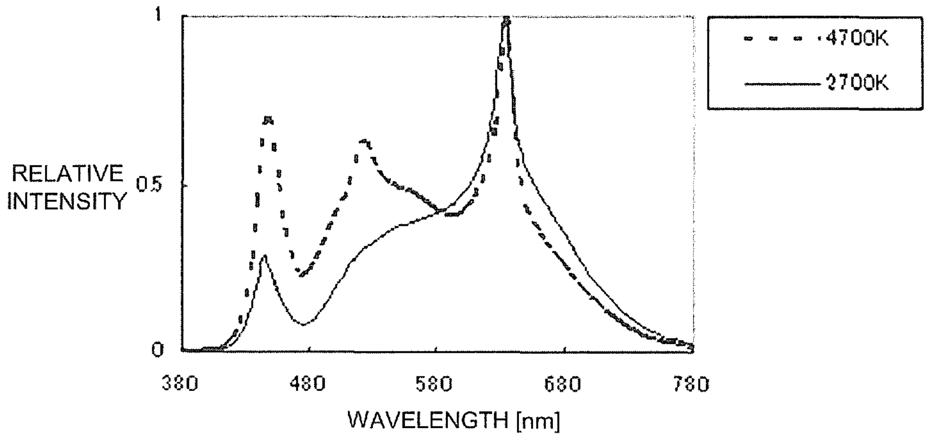
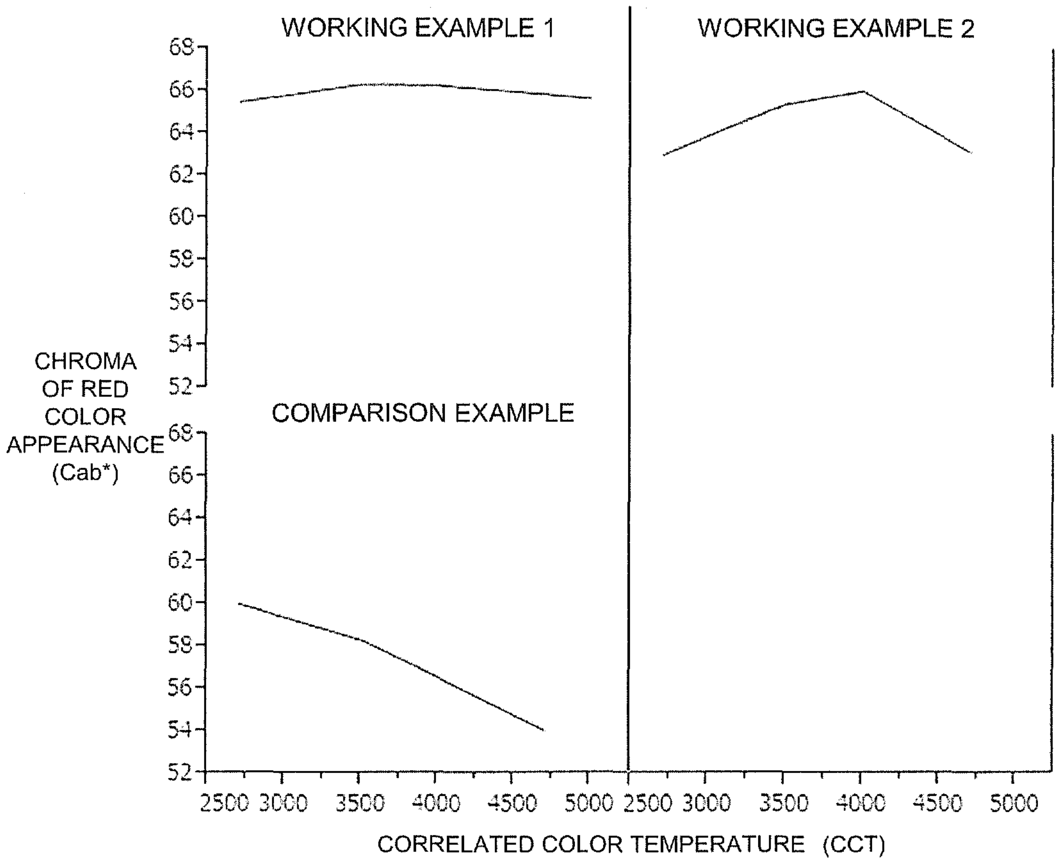

1
RELATIVE INTENSITY
0.5
0
380
480
580
680
780
WAVELENGTH [nm]
4700K
2700K

FIG. 9


WORKING EXAMPLE 1
WORKING EXAMPLE 2
COMPARISON EXAMPLE
CHROMA OF RED COLOR APPEARANCE (Cab*)
68
66
64
62
60
58
56
54
52
2500 3000 3500 4000 4500 5000
CORRELATED COLOR TEMPERATURE (CCT)

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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 6454

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2012/008318 A1 (ISHIWATA TOMOKO [JP] ET AL) 12 January 2012 (2012-01-12) * paragraphs [0053] - [0130]; figures 1-9 * -----	1-3	INV. H05B33/08
			TECHNICAL FIELDS SEARCHED (IPC)
			H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 June 2014	Waters, Duncan

1

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23-06-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012008318 A1	12-01-2012	CN 102341925 A	01-02-2012
		EP 2398079 A1	21-12-2011
		JP 2011204659 A	13-10-2011
		US 2012008318 A1	12-01-2012
		WO 2010126065 A1	04-11-2010

EPO FORM P0459

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Patent documents cited in the description

- JP 2011204659 A **[0002]**
- JP 3040719 B **[0006]**

Non-patent literature cited in the description

- New Version of Color Science Handbook **[0003]**